Landsat DATA USERS NOTES

ISSUE NO. 28 SEPTEMBER 1983

LANDSAT 4 PROBLEMS FORCE EARLY LAUNCH OF D-PRIME

The National Oceanic and Atmospheric Administration (NOAA) has requested that Landsat D', the backup satellite to Landsat 4, be launched as soon as possible because of system problems that have developed with Landsat 4.

Launch of Landsat D' could occur as early as February 1984, which would place it in orbit more than a year ahead of schedule. Even so, the situation is very tenuous, as Landsat 4 could suffer a complete loss of power at any time.

As reported last issue (No. 27, June 1983), two of the solar panels supplying electrical power to the spacecraft are no longer in service due to failure of the cables connecting them to the electrical system. It has been determined that the defect causing the first two failures is present in the cable assemblies connecting the remaining two panels. The problem is with a polyurethane potting material that coats the flat conductor cables between all four panels and the spacecraft: it can not withstand the expansions and contractions caused by the extreme temperature excursions that occur in space.

A reduced mission has been maintained for the last several months because of the limited electrical power available. In spite of this, Landsat 4 has been able to acquire full worldwide multispectral scanner (MSS) coverage. Thematic mapper (TM) data acquisitions have been curtailed due to other problems. If any additional power should be lost, ground controllers will lose command and telemetry capability, and therefore control of the satellite altogether.

In addition to making arrangements to launch D' as requested by NOAA, NASA is studying the possibility of retrieving and repairing Landsat 4 from orbit using the Space Shuttle. Launching the Shuttle into a polar orbit similar to Landsat's is a capability that will not exist until late 1985 or 1986, however. Because Landsat 4 will almost certainly have lost all power before then, and thus maneuvering capability, it will have to be brought down into a "parking orbit" (altitude approx. 335 mi.) while control still exists—there to await a rendezvous with the Shuttle.

NOAA has decided to do this at the first sign of failure in either of the solar power panels that are still operating. Until that maneuver becomes necessary, routine collection of MSS data will continue.

It is realized that a break in service will occur if Landsat 4 must be deboosted before Landsat D' can be launched. A lower orbit for Landsat 4, while keeping open the possibility of Shuttle retrieval, would mean an end to any useful imaging operations.

NOAA and NASA have taken steps to assure that the problems that have occurred aboard Landsat 4 do not happen again aboard Landsat D'. Failure of Landsat 4's X-band transmitter in its wideband communications module last February (see Issue No. 26) has prevented the receipt of data from the TM sensor since that time. Re-establishment of a TM data link has been totally dependent on the success of the Tracking and Data Relay Satellite (TDRS) system. To prevent another such failure, the Landsat D' frequency source amplifiers in both the X-band and Ku-band systems have been redesigned with lower drive levels into the second stage amplifiers. The mounting of certain critical transistors in the amplifiers has also been modified to relieve thermal stress.

Failure of a tantelum capacitor in the primary command and data handlng computer has also been a problem, forcing a switch to redundant electronics shortly after launch last year. Should the redundant system now fail, control of the satellite would be completely lost. The control units on Landsat D' have therefore been redesigned with ceramic capacitors.

Finally, to ensure the source of power aboard the satellite is not again jeopardized by faulty cable connections, the power cables leading to the solar panels have been redesigned to include conventional round stranded wire in a woven flat cable configuration. Crimp truncations at the connector and stress relief clamps and loops at either end have been provided, as well.

It was planned that Landsat 4 would have a mission life of three years, requiring no backup until 1985. At that time, Landsat D' was to be launched and provide service until 1988. If Landsat D' is to be launched early, NOAA will have to decide sooner than originally planned what to do for a follow-on after D'.

INSIDE:

Pecora VIII

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TDRS NOW IN PROPER ORBIT

After 58 days of delicate maneuvers, NASA engineers succeeded on June 29 in placing the first of the Tracking and Data Relay Satellites, TDRS-A, into geosynchronous orbit.

TDRS-A had failed to achieve a correct orbit following deployment from the sixth Space Shuttle mission last April 5, 1983. (See issue No. 27 of the Landsat NOTES.) Over a period of many weeks, the satellite's attitude control thrusters were used to boost it from an initial low elliptical orbit (perigee of 13,574 mi.) to its proper geosynchronous orbit at 22,300 mi. above the Earth. The satellite is now located at 67°W. longitude, which is over the equator above northwest Brazil. Its final location will be at 41°W. longitude over the Atlantic, just off the east coast of Brazil.

TDRS EAST

The original schedule for TDRS-A provided for 90 days of testing before the satellite could be declared operational. One of the tests was to be a demonstration of communications capability with Landsat 4. Although a string of failures aboard Landsat 4 have complicated matters, several test transmissions were run successfully in mid-August. Both MSS and TM data were transmitted through the Ku-band link, resulting in several dozen scenes of both MSS and TM data being received at the White Sands, New Mexico, TDRS ground reception station. Thirty-four MSS scenes were processed and subsequently entered into the Landsat archive. NASA has attempted to process 14 of the TM scenes through the TM Image Processing System (TIPS) (see TM articale this issue). Further tests between Landsat 4 and TDRS are scheduled.

Another demonstration of TDRS capability is to take place as part of the eighth Space Shuttle mission, which was launched on August 30. Both the Landsat 4 and the Space Shuttle tests were supposed to be conducted before TDRS could be used operationally to support the Spacelab 1 mission aboard Shuttle number 9.

Operational use of TDRS for Landsat 4 data relay has been the only hope for receiving TM data following failure of Landsat 4's X-band transmitter last February.

TDRS-A is one of two identical communications relay satellites that are to form a worldwide, full-time communications link for the transmission of Landsat data, as well as data from up to 26 other space platforms, to Earth. (A third TDRS will be launched as an in-orbit spare.) TDRS-B had originally been scheduled for launch on the eighth Shuttle Mission this August, but it has been postponed idefinitely. Review of the Inertial Upper Stage (IUS) rocket which caused the TDRS-A deployment problem is still in progress. A likely cause for the IUS failure may have been a defective inflatable ring that is necessary to move the motor nozzle, thus allowing the spacecraft to be "steered."

Assuming the IUS problems are resolved in the next several weeks, TDRS-B could be launched as early as March 1984 as part of Shuttle mission 12. After luanch, it will be positioned at 171°W. longitude over the western Pacific Ocean.

TDRS WEST

INDUSTRY PROPOSALS TO BE SOLICITED SOON

The Source Evaluation Board (SEB) for Civil Space Remote Sensing, established by the Department of Commerce earlier this year, is close to issuing a formal Request for Proposals (RFP) on the transfer of the operational land and meteorological satellite systems to the private sector.

The SEB plans to release a draft RFP to industry by the end of September. Industry comments will be due 30 days after release, followed by issuance of a formal RFP in early December 1983.

Prior to release of the draft RFP, the Department of Commerce will conduct an orientation program for prospective offerors to enable them to learn the current status of the civil operational remote sensing system including the various command, control, and processing centers. The program is to occur during the month of September and will include a presentation of the overall system plus opportunities for on-site observation of the Government's satellite operations.

The Department of Commerce, through NOAA, currently owns and operates the U.S. civil operational satellite remote sensing systems. These include the Geostationary Operational Environmental Satellites (GOES), the polar-orbiting meteorological satellites (NOAA series), and the land observing satellites (Landsat). The GOES and NOAA satellites together are known as the Metsat system. Either the Metsat or the Landsat system, or a combination of both, could be the subject of the proposals being solicited to accomplish transfer to the private sector.

LANDSATS 2 & 3 DEAD

Landsat 2 was commanded into a non-recoverable mode on July 27, 1983, during orbit number 43,340.

This was slightly earlier than the planned permanent retirement date of September 30, 1983, but satellite attitude control and power could not be maintained. All radiation from the satellite ceased at 7:18 p.m., local time, while it was over the Fairbanks, Alaska, ground station.
During its 8½-year life, Landsat 2 collected 185,105 unique scenes of the Earth for the world's resource data archive.

Landsat 3 was similarly commanded into a non-recoverable mode at 3:30 p.m. EDT, September 7, 1983, during orbit number 28,055. In the 5 years this third satellite of the Landsat series was in service, it acquired 324,655 MSS scenes, not all of which were processed to the archive.

NOAA'S ENVIRONMENTAL SATELLITE DATA ARCHIVE

NOAA's Satellite Data Services Division (SDSD) functions as the official U.S. archive for all data and information from NOAA's geostationary and polar-orbiting satellites, i.e., the Metsat system, as well as several NASA experimental satellites and some of the U.S. Defense Meteorological Program satellites.

As a part of the National Environmental Satellite, Data, and Information Services (NESDIS), SDSD is located in the World Weather Building near Washington, D.C. This arrangement gives the Division access to near-real-time data concerning the operational environmental satellites under NOAA's management. It also facilitates the transfer of digital tapes and photographic negatives between the two organizations whenever the need arises.

The Satellite Data Services Division's archive dates back to April 1960, with data from the original TIROS-1 satellite, and continues through the present. Included in the archive today are data from the complete TIROS series, ESSA series, ITOS/NOAA series, and ATS/SMS/GOES series of spacecraft.

Currently, SDSD is receiving digital data and film products from the two operational geostationary satellites—GOES-East and GOES-West—every ½ hour, 24 hours a day, in addition to data from the polar-orbiting satellites, NOAA-7 and NOAA-8, plus

NASA's NIMBUS-7 with its experimental Coastal Zone Color Scanner. Over 10 million photographic negatives and the equivalent of over 250,000 computer-compatible tapes have been archived to date.

Products available from the Satellite Data Services Division include both full- and reduced-resolution digital data from the NOAA satellites, as well as photographic prints measuring up to 30 by 30 inches. Prices for a digital tape start at $99 each; 10-inch black-and-white photographic prints start at $8.50. Analysis charts (both historical and current) are available on a subscription basis, with weekly mailings.

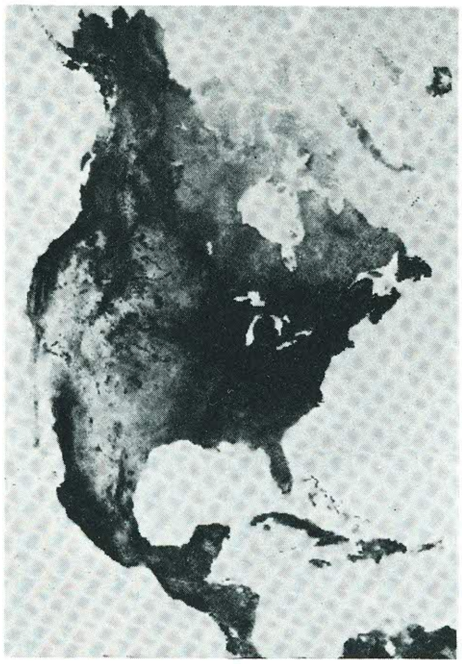
Several products available through the Division are currently being used by organizations who are also familiar with Landsat data. These products include tapes and film of images acquired by the SEASAT Synthetic Aperture Radar (SAR) sensor, and high-resolution (1.1 km) data from the Advanced Very High Resolution Radiometer (AVHRR) sensors aboard the present NOAA-series polar-orbiting satellites. SAR data, with 24-meter resolution, have provided a wealth of information for the geologic and oceanographic community, offering coverage from July-October 1978 over the U.S., Canada, Central America, Western Europe, Greenland, Iceland, and the surrounding waters. AVHRR data,with 1-km resolution as compared to Landsat's 80-meter resolution, have proven useful as a source of multichannel information which can be acquired twice daily over any specified region of the world.

Two new services being provided by the SDSD include near-real-time data reproduction and the availability of a new Vegetative Index product. The near-real-time service permits the Division to tap into the operational data acquisition stream to copy data within 1-2 days of acquisition, thereby making fast turnaround times available to the customer. The Vegetative Index product is a "greenness" image utilizing AVHRR channels 1 and 2. As can be seen in the accompanying examples, it can be used as an indicator of plant growth stages in the area imaged and is available globally. (Also see December 1982 issue of the Landsat NOTES, p. 10.)

The staff at SDSD—meterologists, oceanographers, systems analysts, and others—is ready to assist users in obtaining environmental remote sensing data to fit their needs. Additional information on SDSD products, services, ordering procedures, and prices can be obtained by contactng: NOAA/NESDIS, Satellite Data Services Division, World Weather Building - Room 100, Washington, D.C. 20233. Telephone: (301) 763-8111.

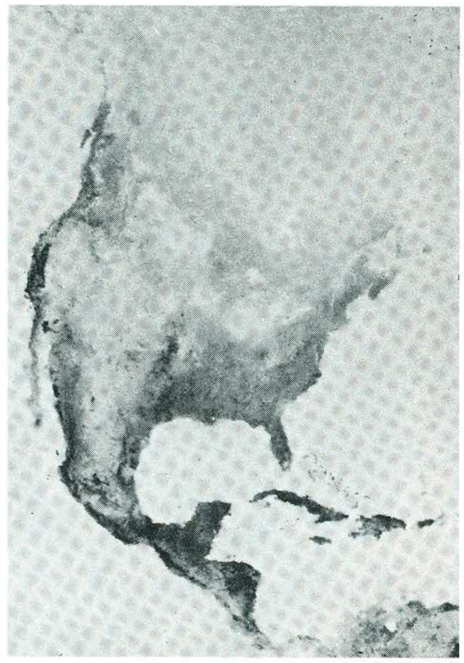
NEW INDEXES AID IN VEGETATION MONITORING

(Now Available from the Satellite Data Services Division, NOAA/NESDIS)



A

Aug. 23-29, 1982



B

Mar. 21-27, 1983

The examples above show the seasonal differences in vegetation (Vegetative Index) in North America. The distribution for the week of August 23-29, 1982, and March 21-27, 1983, appear. These displays are averaged composites of data acquired from the NOAA-7 Visible and Near Infrared sensors. The darker areas represent high chlorophyll or active growing areas; the increasing lighter tones represent desert or dormant land areas, as well as snow-covered and water surfaces. This product is produced weekly for each hemisphere. For more information about the Vegetative Index contact Dr. Dan Tarpley, NOAA/NESDIS, Satellite Applications Lab E/RA3, World Weather Building - Rm 806 Stop I, Washington, D.C. 20233.

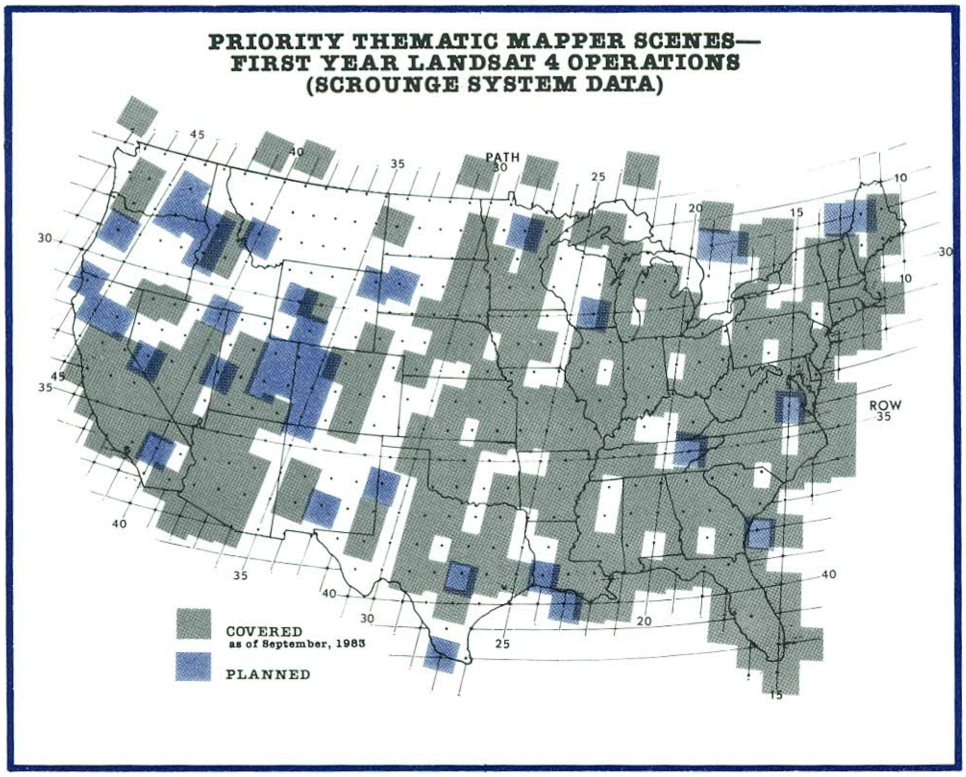
TM ACQUISITIONS IN 1983

Earlier this year, NASA released detailed information concerning the locations of TM scenes that it planned to acquire and process during the first 12 months of Landsat 4 operations. Almost all of these data (which are in Scrounge format, as explained in the TM article elsewhere in this issue) are over the United States, and they are identified on the accompanying map (next page) by WRS path-row point. The shading represents the approximate extent of individual scene coverage.

Information regarding specific data availability should be requested from: NOAA Landsat Customer Services, Attn: TM Coordinator, Mundt Federal Building, Sioux Falls, SD 57198. Telephone: (605) 594-6151.

THEMATIC MAPPER RESEARCH AND DEVELOPMENT PERIOD

August 1, 1983, marked the beginning of the Landsat TM Research and Development (R&D) period and startup of the new TM Image Processing System (TIPS) at the Goddard Space Flight Center (GSFC). The TM R&D Period is scheduled to last until January 31, 1985, when NASA will turn over an operational TIPS to NOAA. Superseding the TM Scrounge processing period, which lasted from September 1982 to July 31, 1983, the TM R&D period can be characterized as a time of system and product evaluation. NASA, in cooperation with NOAA, intends to use the TM R&D period to correct any TIPS hardware, software, or operational problems that might prevent full TM processing operations by NOAA.



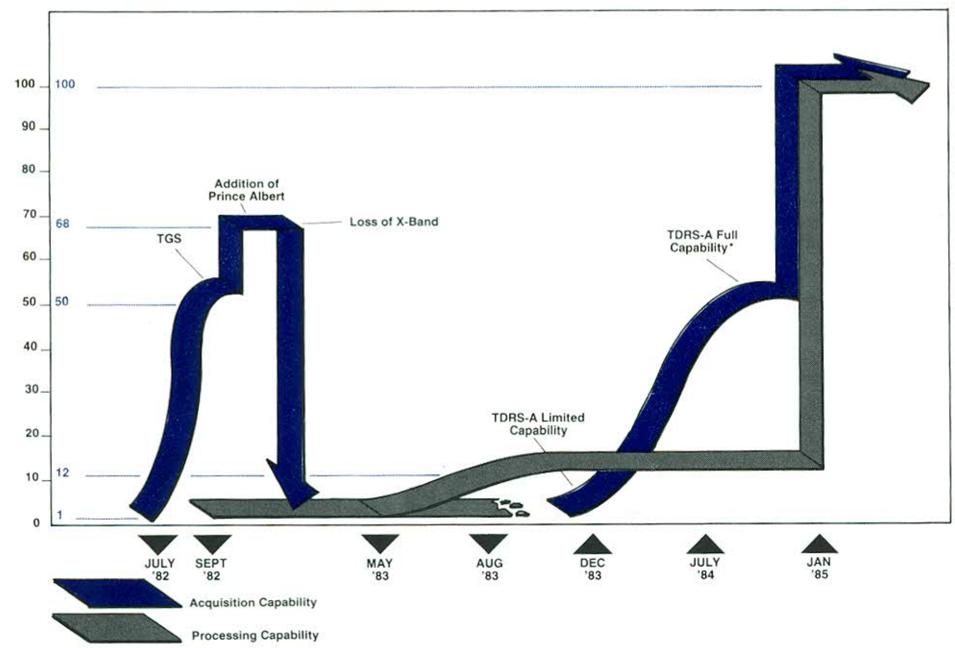


Figure 1. TM Acquisition and Processing Profile

TM Acquisition and Processing Profile

Figure 1 depicts the domestic TM acquisition and processing profile. The horizontal axis is marked with Landsat TM milestones. The vertical axis measures scenes per day, both acquired and processed. Note that the numbers on the vertical axis refer to capabilities rather than to actual scenes acquired and processed in the operational setting. The blue arrow represents acquisition capability, while the black arrow represents processing capability.

After launch, the acquisition rate rose to 50 scenes per day. This rate was achieved through use of the X-band reception capability of the transportable ground station (TGS) at GSFC. With the activation of an X-band capability at the Canadian ground station at Prince Albert in the latter part of 1982, overall TM domestic acquisition capability rose to 68 scenes per day. This level continued until the February 1983 failure of the satellite's X-band transmission system.

In September 1982, TM Scrounge processing began. During this period, TM scenes were processed at the rate of 1 scene per day. The large difference between scenes acquired and scenes processed was due to the fact that TM scenes were being acquired at maximum capability to protect against early sensor or spacecraft failure. During this period, about 6,300 TM scenes were acquired and placed in a separate archive at GSFC. Approximately 275 of those scenes were processed through the Scrounge system and placed in NOAA's TM archive at the EROS Data Center (EDC), in Sioux Falls, South Dakota.

At the May 1983 milestone, the black arrow splits. The lower portion refers to continued Scrounge processing at 1 scene per day while the upper portion rises gradually. This "ramp" marks an operational readiness period during which preparations were completed for the TM R&D period. Although the Scrounge period officially closed on July 31, 1983, work in progress continues into September 1983.

In December 1983, the blue acquisition arrow emerges again because the first of the two TDRS's will be released for limited operational use, allowing TM acquisitions via the Ku-band link. It is important to note that this acquisition capability is dependent upon the TDRS system's schedule and the Landsat 4 power situation. The black processing arrow by this time depicts 12 scenes per day, based on a 5-day work week, which is the goal of the TM R&D period. This phase continues until July 31, 1984.

August 1, 1984, begins the initial TM operational period. From August to January 31, 1985, TIPS will be tested in an operational environment prior to turnover to NOAA. NOAA operation begins on January 31, 1985, and is characterized by both arrows rising to 100 scenes per day, i.e., full TIPS operational capability.

TM Scrounge System

The TM Scrounge processing system, as its name suggests, involved a variety of data processing and control elements located at both GSFC and EDC. Its purpose was to process "early-access" TM data in an engineering mode during the period between TM instrument activation and the beginning of TIPS processing.

During the Scrounge period, digital user products consisted of full-scene CCT's packed at 6250 bits per inch in a band-sequential (BSQ) format. Photographic user products consisted of black-and-white, false-color, and natural-color images in sizes ranging from 241 mm to 40 inches.

The TM R&D System

The objectives of the TM R&D period are to: (1) assess the capability of the TM sensor, (2) demonstrate operational TIPS feasibility, and (c) encourage users to become familiar with the higher data rate and resolution of TM imagery.

Results from system engineering evaluations, image data quality assessments, and applications investigations will be used to characterize TM data and to detect facility and/or data quality problems throughout the R&D period. Necessary system upgrades, algorithms enhancements, or operational changes will be made to meet performance and quality requirements. This will be a progressive process, with the goal being delivery of a fully tuned, operational TIPS in January 1985.

Standard TM processing during the R&D timeframe consists of eight major functions, which are as follows:

User Request Processing. The series of TM processing events is initiated by a user request for the acquisition of TM data or for a product requiring archived data (termed a retrospective order). All such requests are received by NOAA Landsat Customer Services at EDC. NOAA forwards these requests on a digital tape to GSFC for entry into a data base reserved for this purpose.

Spacecraft Scheduling. Once a day, TM acquisition requirements based on user requests are merged with MSS acquisition requirements. This information is used to schedule and command the spacecraft, which acquires the requested scenes consistent with station coverage and spacecraft power and thermal restrictions.

Telemetry Processing. Spacecraft telemetry data, used in subsequent processing of TM imagery, are transmitted to the ground by a 32-kbps digital signal modulated on an S-band carrier. These data are recorded on a payload correction data (PCD) tape which includes angular displacement sensor data, gyro data, attitude and ephemeris data, sensor housekeeping data, and the spacecraft time code.

Image Acquisition. Up until February 1983, TM coverage was acquired and downlinked directly to a transportable ground station at GSFC or to Canada's Prince Albert receiving station via an X-band communications link. With TDRS, TM coverage will be transmitted via a Ku-band link from the Landsat 4 spacecraft (and/or Landsat D') to the TDRS-A vehicle for downlink to White Sands, New Mexico. From here, the data will be retransmitted via Domsat to GSFC. GSFC will record incoming TM video data on high density digital tape (HDT) and generate tape directories, mirror scan correction data, and quality information.

Systematic Correction Data (SCD) Generation. After image acquisition a tape of systematic correction data (SCD) is generated. This involves: (1) correcting and validating the mirror scan and payload correction data recorded earlier, (2) providing for image framing by generating a series of scene center parameters, (3) synchronizing telemetry data with video data, (4) estimating the deviation from linear motion of the scan mirror and the scan line correction

Table 1. TIPS Quality and Performance Requirements During the R&D Period

Quality Performance Area	Requirement
Radiometric Accuracy:	±1 quantum level
Geometric Accuracy*	
Temporal Registration:	0.3 pixel** (90% of the time)
Geodetic Accuracy:	0.5 pixel** (90% of the time)
Turnaround Time:	48 hours maximum: Raw data to: •Product HDT •Product Film •CCT
Maximum Utilization:	85% of 8-hour day

*With sufficient correctable ground control points
**With a priori jitter correction

Table 2. TIPS Operational Characteristics During the R&D Period

Characteristics	Operational Goal
Acquisition Level:	50 TM scenes per day via TDRS-A Ku-band link
Processing Level:	12 scenes per day to archival level (HDT-AT) 12 scenes per day to fully processed film film (241 mm, HDT-PT) 2 scenes per day to CCT-A or -P
Shift and Processing Resources:	1 TM processing string, 1 shift per day, 5-day work week
Map Projections Supported:	Space Oblique Mercator Universal Transverse Mercator/Polar Stereographic
Resampling Algorithms:	Cubic convolution Nearest neighbor

mechanism, (5) generating benchmark systematic correction matrices for specified map projections, and (6) producing along- and across-scan high-frequency scan line matrices. These data are processed and reformatted onto a digital tape which is used during the geometric correction process.

Archive Generation. Archive generation occurs in four stages. First, the TM video data on HDT and the corresponding SCD tape are input to TIPS. Second, TIPS screens the raw TM video data, accumulates scene content, builds digital value histograms, extracts calibration values, and selects control point neighborhoods in preparation for radiometric and geometric correction computations. Third, TIPS calculates radiometric lookup tables, using computed gain and offset values and, as an option, generates scene content histograms. Based on the SCD and control point correlation information, TIPS then computes geometric correction matrix values. Header, ancillary, annotation, and trailer data are also formatted during this stage. Finally, during the fourth stage, TIPS decommutates, aligns, and converts the data from band-interleaved-by-pixel to band-interleaved-by-line (BIL) format, then applies radiometric corrections to the data (using the lookup tables generated earlier), appends the geometric correction information, and writes a partially processed TM archive data tape, called an HDT-AT. A by-product of this process is the recording of 70-mm film for quality control and ground control point selection purposes.

Initial Product Generation. During initial product generation, TIPS reformats the BIL tape to BSQ format, applying the geometric corrections computed during archive generation, and creates the necessary header, annotation, and trailer data files. A fully processed TM data tape (an HDT-PT) is subsequently written.

Final Product Generation. Final TIPS products include either partially or fully processed data on CCT's or fully processed data on 241-mm film. These are generated directly from the corresponding HDT-AT's (partially processed) or HDT-PT's (fully processed) in the TM Tape Archive. The necessary CCT-A's or CCT-P's are shipped to the NOAA Landsat archive in Sioux Falls, South Dakota, where they are stored and duplicated for user product generation. The 241-mm film master (of "P" data) is also shipped to the NOAA archive, where it is used to create user film products.

Ground Control Point (GCP) Processing. Though not an on-line process during standard TM image processing, the GCP Library Build function of TIPS depends on both archival and final product processing for its data input. Using 70-mm film recorded during archive data generation, a control point technician selects cloud-free scenes. Corresponding 241-mm film of the selected scenes is produced during final product generation. Easily identifiable features such as highway intersections are located on a standard map and their coordinates digitized. Control points are then generated from the appropriate HDT-PT. As a final step, data identifying both the control point film chip and the control point are digitized and stored in a permanent data base.

The GCP Library Build function will commence in November 1983 at a rate of 1 scene per day. This rate will increase to 4 scenes per day by January 31, 1985. During the TM R&D period, the accuracy and need for seasonal GCP's will be determined.

R&D Products.

The products introduced with the TM R&D period are standard products whose formats are expected to remain unchanged for the life of the Landsat 4 and D' Programs. While image quality may improve due to processing algorithm refinement, etc., the formats of the images will be constant. The photographic products are 241-mm full scenes, available in black-and-white or color. For each scene of processed data, seven black-and-white images (one per band) are available. Color composites of these images are available in three-band combinations.

Digital products are available on CCT's at densities of 6250 or 1600 bits per inch. One quadrant of scene data is contained on one 6250-bpi or three 1600-bpi CCT's. Product options include:

- BSQ or BIL formats
- Radiometric corrections only ("A" data) or both radiometric and geometric corrections ("P" data)
- Nearest neighbor resampling or cubic convolution
- Space Oblique Mercator map projection or either the Universal Tranverse Mercator or Polar Stereographic projection:

BIL CCT's are not currently available, but they will be available later in the R&D period.

For descriptions of TM photographic and CCT product formats, see the accompanying articles in this issue of the Landsat Data User NOTES.

Data Availability

In the absence of any newly acquired TM data, TIPS is processing pre-recorded scenes acquired prior to the X-band transmitter failure. Of the approximately 6,300 TM scenes archived during that time, approximately 1,900 scenes have been selected for processing. Since TIPS processes TM data on a swath basis rather than on a scene basis, additional archive scenes will be generated.

Orders for TM data products and acquisitions must be placed with NOAA Landsat Customer Services, Mundt Federal Building, Sioux Falls, SD 57198. Telephone: (605) 594-6151.

INTERNATIONAL STANDARD TM CCT'S

TIPS introduces a standard TM CCT product that contains one Worldwide Reference System (WRS) scene quadrant, meets detailed international standard requirements as set by the Landsat Ground Station Operators Working Group (LGSOWG), and which provides two levels of support information. A brief description of this new product follows below, but for additional information contact NOAA Landsat Customer Services, Attn: TM Coordinator, Mundt Federal Building, Sioux Falls, South Dakota 57198. Telephone: (605) 594-6151.

The fact that the CCT product carries data for one-fourth (one quadrant) of a scene is important to users, who must now place orders on a per-quadrant basis. To obtain a full scene, all four quadrants must be ordered. Determining which quadrant of a scene covers a particular site is relatively simple with the use of WRS maps, since the division of a scene into quadrants is based on the WRS scene center. This division is illustrated in Figure 2 (for geometrically corrected data). The scene is divided horizontally between the line containing the WRS center pixel (line 2983) and the following line. It is divided vertically between the WRS center pixel and the following pixel, with the vertical division skewed parallel to the image skew. Thus, the WRS center pixel becomes the last image pixel of the last line of quadrant 1, and within each quadrant are equal numbers of image pixels per line (excluding fill).

Note that the number of image pixels per line varies from quadrant to quadrant depending on the cross-track offset of the WRS center from the mid-scan point. In other words, a quadrant may contain less than or more than a quarter scene. Blank fill is added to the end of lines in quadrants 1 and 3 and to the beginning of lines in quadrants 2 and 4 such that total line length per quadrant (including all fill) is 4220 pixels.

The division of a geometrically uncorrected scene into quadrants is such that an equivalent ground area is covered for a quadrant of uncorrected data as for a quadrant of corrected data. However, the division is not as geodetically precise. In this case, the horizontal division is between forward-reverse scan pairs such that quadrants 1 and 2 end with the scan pair group of lines containing the WRS center. The vertical division is between the WRS pixel (pixel n) and the following pixel (pixel n + 1). All lines are divided at the same pixel number (between pixel n and n + 1), producing four rectangular arrays. For recording on CCT's, fill is added to the end of lines in quadrants 1 and 3 and to the beginning of lines in quadrants 2 and 4 such that total line length per quadrant (including fill) is 3500 pixels. See Figure 3.

The standard TM CCT quadrant product is recorded on one tape at 6250 bpi or on three tapes at 1600 bpi in BSQ or BIL format. Each quadrant has all information necessary to identify, process, and assess the data. The format is similar to that for MSS data in its general organization and in adherence to the international LGSOWG standards. (See Issue No. 21, January 1982, of this newsletter for further information on the international CCT standard). It differs in that the data for one quadrant are divided into two logical volumes. The first logical volume, called the Imagery Logical Volume, contains the image data, preceded by a file of header, map ancillary, and radiometric ancillary information, and followed by a trailer file. The format of this volume has been standardized to a detailed level, so that all TM CCT's, regardless of facility or country of origin, will have Imagery Logical Volumes of identical formats. The information in this volume is considered independent of processing system and sufficient for the needs of most users. All records are 4320 bytes or less in length and are coded in ASCII and/or unsigned binary only.

The second volume, the Supplemental Logical Volume, contains information specific to the processing system and varies in format and content from country to country. For U.S. data, there are two formats that this volume can take, one for geometrically corrected and one for geometrically uncorrected data. Both follow international standard conventions (begin with standard volume directories, introduce files with descriptor records, employ standard record introductions, have 180-byte-multiple record lengths, etc.).

The international format is designed to promote ease of access to data of interest to the majority of users, while preserving detailed processing and quality information of interest to specialists. This ease of access will be more fully realized through use of the international LGSOWG standard CCT Software Library that

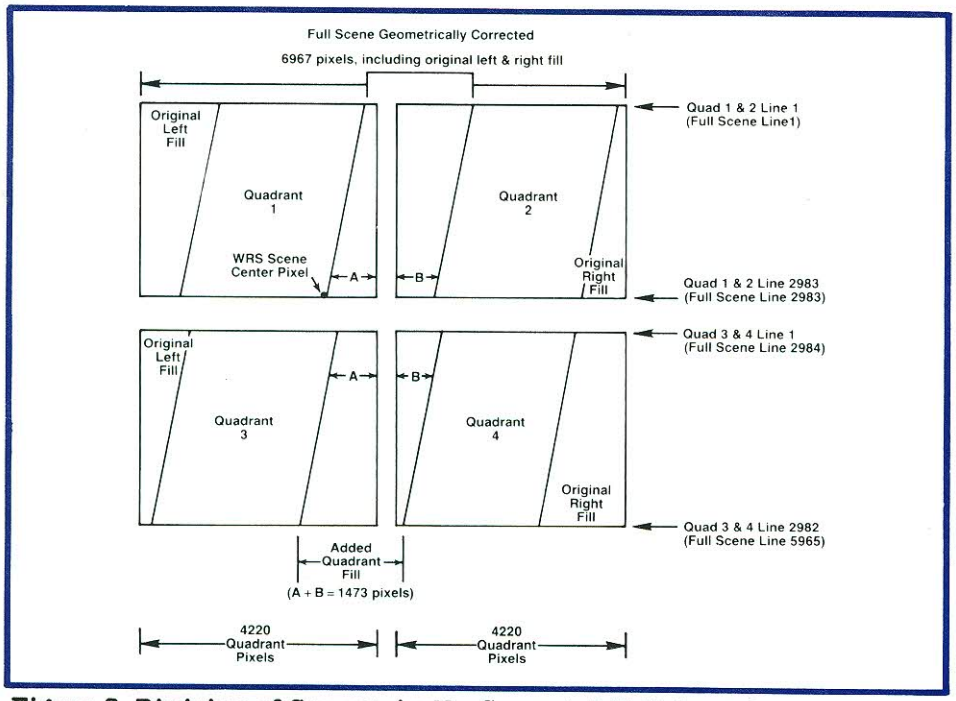


Figure 2. Division of Geometrically Corrected Full Scene (6967 Pixels x 5965 Lines) into Quadrants

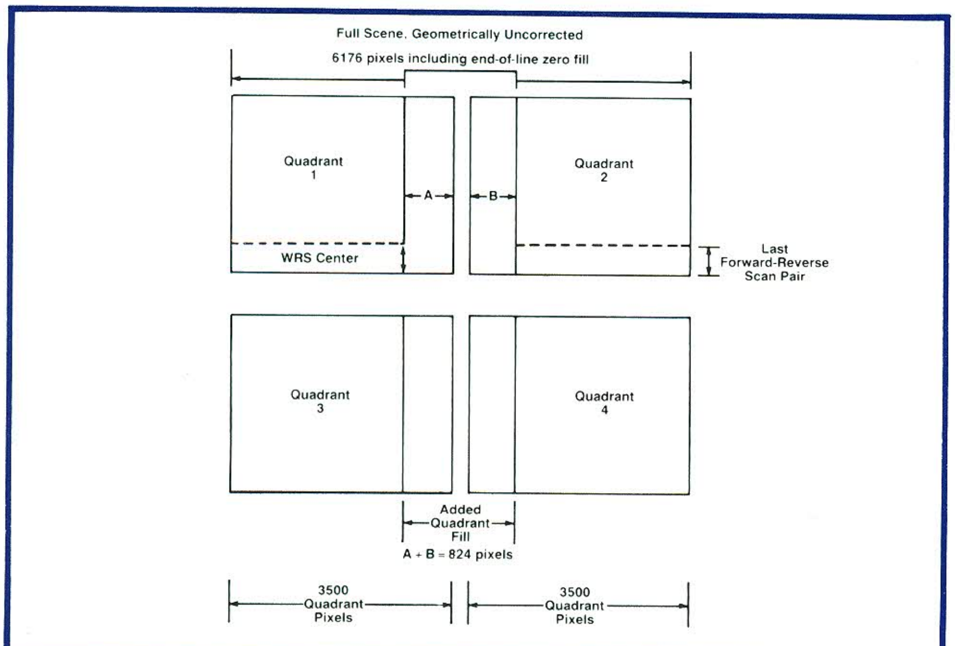


Figure 3. Division of Geometrically Uncorrected Full Scene (6176 pixels x 5984 lines) into Quadrants.

is currently being developed and documented by LGSOWG's Landsat Technical Working Group (LTWG). When completed, it will be available through: NOAA Landsat Customer Services, Attn: TM Coordinator, Mundt Federal Building, Sioux Falls, SD 57198. It is a highly machine-independent FORTRAN package which reads, verifies, and writes CCT's in any international standard format. With it, users can make optimum use of standard formats since most format differences become transparent. For example, once it is installed in an interactive environment, a user will be able to display desired imagery with only three calls—without prior knowledge of the source format (other than that it is a standard format and contains imagery). Associated information (identification, ancillary, quality, etc.) can be extracted with similar ease. Announcement of availability of this package will be forthcoming in Landsat Data Users NOTES.

TM PHOTOGRAPHIC PRODUCTS

TM data provide significantly more information than data obtained by previous Landsat sensors. The resolution, or number of pixels per image,* is up from 10.6 million 57-m pixels for MSS data, to 41.6 million 28.5-m pixels for TM data. The precision of each pixel has increased from a 6-bit MSS pixel (64 gray levels) to an 8-bit TM pixel (256 gray levels). The spectral range is also expanded, with the TM detectors responding to seven spectral bands as opposed to the MSS's four. Each added dimension in-

Each added dimension introduces new variables to be addressed in defining a standard photographic product.

Limitations to the array of possible standard products are those imposed by the processing/production system. Kodak type SO394 241-mm recording film is exposed on a Goodyear laser-beam recorder (LBR) in the TM Image Processing System at GSFC. The seven images for each scene are developed in a Versamat 11CM processor using Kodak 885 black-and-white chemistry.

This first-generation positive film is inspected at GSFC, and then shipped to the NOAA archive facility at the EROS Data Center in Sioux Falls, South Dakota, where user products, both black-and-white and color, are reproduced and distributed. While both the processing system at GSFC and the production system at EDC allow for considerable versatility in photographic format and content, the set of seven black-and-white images transferred between the two facilities becomes the archival source for all subsequent photographic user products. This specific system limitation requires the definition of one format which will apply to all film products, and of one approach to content (relationship of film density to digital values and hence scene radiance) which will allow for balanced contrast in both black-and-white and color-composite products.

The format for TM photo products, introduced with the initiation of TM R&D production in August 1983, is illustrated in Figure 4. This format is very similar to that for MSS images, with one 241-mm photo covering one WRS scene and bearing associated annotation and tick marks. There are two significant differences in the TM product, however. The first is a considerably smaller spot size (0.0285 mm²) due to the high resolution of TM data. (The MSS spot size is 0.057mm²). This imposes more stringent placement accuracy tolerances on the film recording process in order to accurately register images for color products. To do this, the LBR is specified to record within these tolerances. The second difference is the inclusion of a second gray scale. The first (top) gray scale presents 16 density steps relating linearly to a set of digital values ranging from 0 to 225. These are the digital values of the data as they have been radiometrically and geometrically processed and recorded on high-density tape. The second (bottom) gray scale has 16 steps also, but the densities of these steps reflect the result of the "contrast stretch" that is applied to the data in the photographic recording process. That process affects relative image brightness values, and the variable gray scale at the bottom is the user's means of estimating that effect.

While the film product standard format is considered fixed for TM products, the nature of the contrast stretch employed in the recording process may be refined or modified during the TM R&D period. The considerations involved in assessing the various stretch techniques are photographically oriented, since this step occurs during the film recording process and therefore affects photographic data only. (Digital data products are produced from the same master tapes that are used as film recording process input.) Objectives vary, but one general priority is to be able to produce cosmetically pleasing color imagery which takes advantage of available film dynamics while maintaining data integrity and precision. Options vary from a

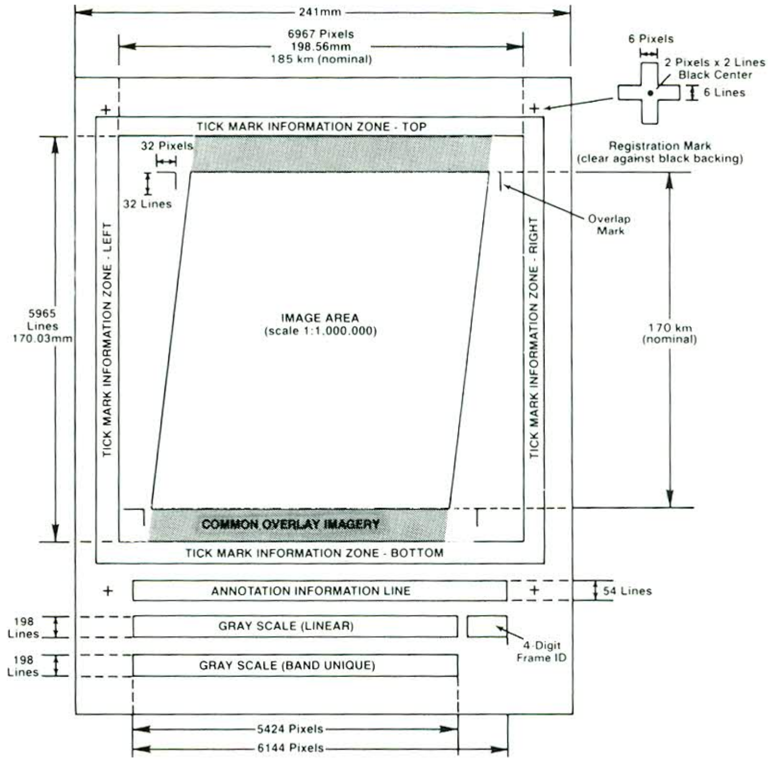


Figure 1. Symbolic Representation of an Image on 241-mm Film (pixel size=0.0285mm²). Not to Scale.

*In geometrically corrected, full-resolution imagery (i.e., excluding TM band 6).

linear translation of digital values to film spot density (no stretch) for all data, to applying individual stretches to each band of each scene. Another option is to perform scene-dependent stretches based on scene content variables (e.g., brightness value frequencies or cover type) or on "systematic" variables such as seasonal variations in sun angle. (This option, incidentally, presents an interesting prospect which will be assessed during the R&D period.)

In initiating a standard TM product for the R&D period, Landsat managers selected the per-band stretch option. Standard "average" histograms were determined for each band, and transformation curves were derived which stretched the data over a range where 0 (digital value) equals a density of 2.20 (darkest) and 255 (digital value) equals a density of 0.20 (lightest).

Figure 5 illustrates the derived "average" histograms (displayed for ±1 sigma of all pixels) and their digital-value-to-density transformation curves. Note that histograms for band pairs 2 & 3 and 4 & 5 are similar enough to warrant one transformation curve each. The curves were developed through a cooperative GSFC-EDC analysis, in which independent investigations were conducted at each facility and the results compared. At GSFC, initial "average" histograms were taken statistically from 12 scenes selected to include variation in season, content (land, water, urban, agricultural, etc.), and geographical location. Using histogram statistics, the "significant average" band minimum value was set to 40, the "significant" high value was set to 170, the end points were left at 0 = 0 and 225 = 225, and a four-point piece-wise stretch was performed for each band. The resulting data were mapped to transformation curves. These curves were then refined through iterative photographic processing and inspection. At EDC a set of curves was developed based on a purely statistical analysis of a larger sample (50 scenes). Comparing the two sets of curves revealed remarkably similar results. The differences between the two sets were examined and certain changes were made, resulting in the compromise curves illustrated in Figure 5.

Figure 5 depicts the relationship which exists between the output densities achieved using the band-unique transformation curves and those that would have been achieved had a linear transformation of intensity been used.

Table 3 relates input digital value to output density for the seven TM bands and the linear gray scale. **These are the lookup values which the LBR will employ in exposing TM images.** As the R&D period progresses and the data base of available TM imagery increases, the applicability of these compromise values will be monitored. Any change deemed valuable (which may include implementation of seasonal sets of lookup tables or scene-dependent tables) will be made in the LBR and reported in future issues of these NOTES.

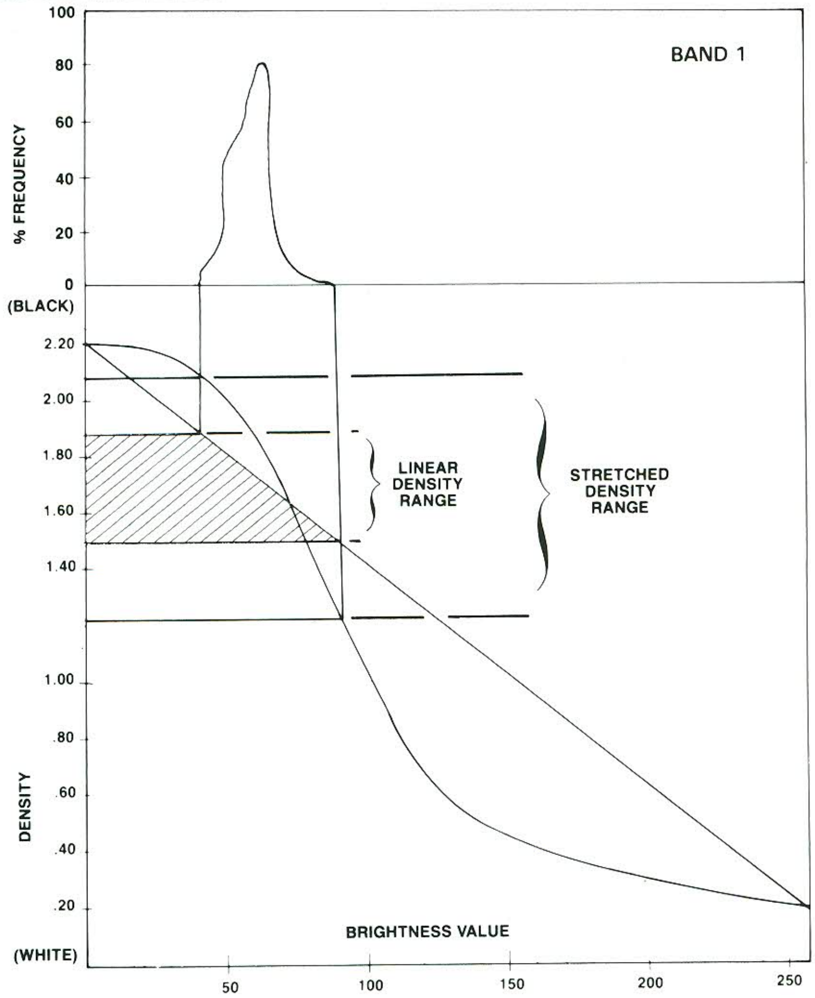


Figure 5.a. "Average" Per-Band TM Histograms and Derived Density Transformation Curves. (Band 1.)

Digital Value	Linear Gray Scale Density	Band 1 Density	Bands 2&3 Density	Bands 4&5 Density	Band 6 Density	Band 7 Density
0	2.20	2.20	2.20	2.20	2.20	2.20
16	2.07	2.17	1.55	1.69	2.20	1.32
34	1.93	2.02	0.98	1.35	2.16	0.88
50	1.80	1.56	0.64	1.12	2.01	0.66
68	1.67	1.12	0.41	0.90	1.76	0.50
84	1.53	0.87	0.32	0.75	1.50	0.41
102	1.40	0.65	0.28	0.60	1.20	0.34
118	1.27	0.50	0.26	0.50	0.95	0.30
136	1.13	0.39	0.25	0.40	0.70	0.27
152	1.00	0.33	0.24	0.34	0.49	0.25
170	0.87	0.30	0.23	0.30	0.32	0.23
186	0.73	0.27	0.22	0.26	0.24	0.22
204	0.60	0.25	0.21	0.24	0.22	0.21
220	0.47	0.23	0.20	0.22	0.20	0.20
238	0.33	0.21	0.20	0.21	0.20	0.20
255	0.20	0.20	0.20	0.20	0.20	0.20

Table 3. TM Lookup Tables, Showing Input Digital Value Versus Output Density

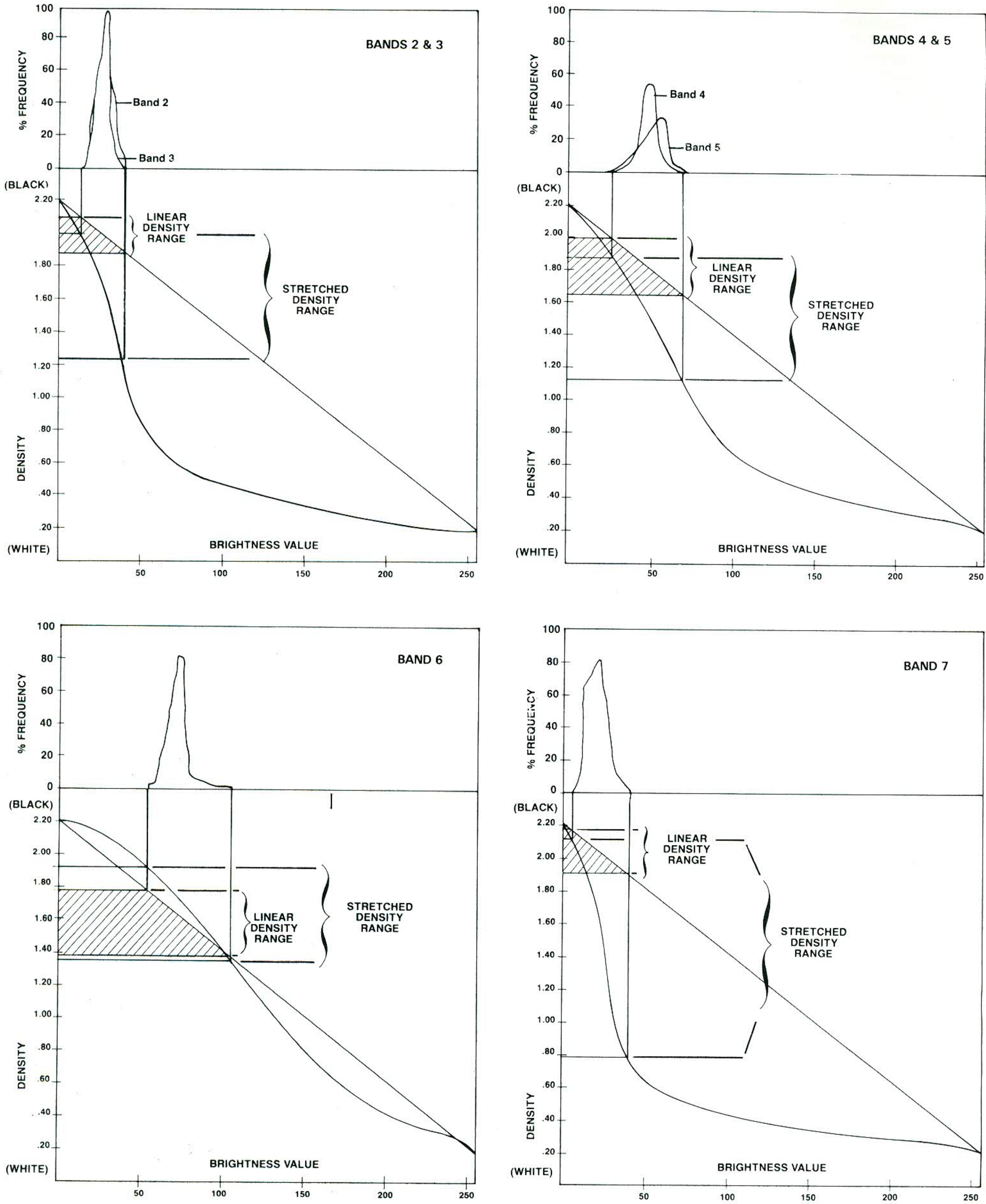


Figure 5.b. "Average" Per-Band TM Histograms and Derived Density Transformation Curves. (Bands 2 through 7.)

RECENT EARTHNET ANNOUNCEMENTS

ESA's Earthnet Program Office in Frascati, Italy, has available about 1200 scenes of TM data acquired between December 1982 and February 1983. All are within the reception range of the Fucino, Italy, ground station, stretching from the Black Sea to the U.K. and from southern Scandinavia to northern Africa.

The tables below list these acquisitions by WRS path and row location and date. For information regarding updates to the list of "processed" scenes (small table), or for other information, contact: Earthnet User Services, Earthnet Program Office, via Galileo Galilei, 00044 Frascati, Italy.

Over 500 color composites derived from data acquired at the Fucino and Kiruna, Sweden, ground stations before the launch of Landsat 4 are also available—at a reduced price. A catalog listing these scenes can be obtained by contacting Mrs. G. Calabresi at the address given above.

Landsat 4 Thematic Mapper Acquisition: Unprocessed
(Acquired from Earthnet)

Path/Row	Date
172/26-26	1-17-83
172/25-37	2-02-83
173/24-39	1-24-83
173/24-39	2-09-83
174/23-40	1-15-83
174/23-40	1-31-83
176/21-43	12-28-82
176/22-43	1-29-83
177/22-43	1-27-83
179/20-44	1-18-83
179/20-44	2-03-83
180/20-44	1-25-83
180/18-42	2-10-83
181/19-45	2-01-83
182/25-34	12-06-82
182/19-45	1-23-83
182/18-44	2-08-83
183/19-46	1-14-83
183/17-46	1-30-83
184/20-46	12-20-82
184/19-45	1-21-83
184/17-46	2-06-83
185/17-45	12-27-82
186/18-47	1-19-83
186/17-46	2-04-83
188/18-47	1-17-83
188/17-46	2-02-83
189/17-46	1-24-83
189/17-46	2-02-83
190/18-31	1-15-83
190/33-46	1-15-83
190/17-30	1-31-83
190/35-45	1-31-83

Path/Row	Date
191/18-45	12-05-82
17-45	1-22-83
16-46	2-07-83
192/16-46	12-28-82
16-46	1-29-83
193/15-45	1-20-83
194/17-44	1-27-83
195/17-44	1-18-83
16-43	2-03-83
196/16-44	1-25-83
16-16	2-10-83
20-44	2-10-83
197/16-43	2-01-83
198/18-42	1-23-83
21-42	2-08-83
199/19-42	1-20-83
200/36-41	12-04-82
17-41	1-21-83
17-41	2-06-83
201/38-40	12-11-82
16-40	12-27-82
38-40	1-28-83
202/18-40	1-09-83
16-40	2-04-83
203/25-39	12-25-82
21-39	1-26-83
204/22-37	1-17-83
17-39	2-02-83
205/17-38	1-24-83
17-28	2-09-83
206/17-37	1-31-83
207/18-34	1-22-83
17-35	2-07-83
208/18-26	1-29-83

Landsat 4 Thematic Mapper Scenes: Processed
(Processed by Earthnet and available as raw data tapes —full scene, seven channel)

Path/Row	Date of Acquisition	Geographic Area
188/31	1-17-83	Italy (Bari)
188/32	1-17-83	Italy (Basilicata)
188/33	1-17-83	Italy (Mount Etna)
188/34	1-17-83	Italy (Calabria)
189/18	1-09-83	Finland
193/23	1-20-83	Germany (Berlin)
194/28	1-27-83	Italy (Lake Maggiore)
195/19	2-03-83	Sweden
195/21	2-03-83	Denmark (Copenhagen)
195/27	1-18-83	Switzerland
198/19	1-23-83	Norway
198/24	1-23-83	Netherlands (Amsterdam)
198/25	1-23-83	Belgium (Brussels)
198/30	1-23-83	France (Toulouse)
201/32	12-27-82	Spain (Madrid)
202/24	2-04-83	England (London)
207/23	2-07-83	Ireland

NEW PUBLICATIONS

A study conducted by the Holcomb Research Institute of Butler University, Indianapolis, Indiana, has been published which reports the effects of Landsat data resolution on classification accuracy and computer time. Entitled **An Estimate of Cost-Effectiveness of Machine-Processing Increased Spatial Resolution MSS Data,** the study covers a range of resolution from 10 to 80 meters for a test site where 100% ground truth was available. Request a copy from: User Affairs Unit, NOAA/NESDIS, E/ER-2, Washington, DC 20233.

RBV MOSAIC

A Landsat 3 return-beam vidicon (RBV) mosaic of the State of Oregon has recently been released. The 1:500,000-scale semi-controlled photomosaic incorporates 74 RBV images, showing many natural and cultural features, particularly the hydrology of the State. To obtain a copy, contact the Environmental Remote Sensing Applications Laboratory (ERSAL), Oregon State University, Corvallis, OR 97331, or any vendor of U.S. Geological Survey map products.

SYMPOSIA

The **9th Annual Remote Sensing of Earth Resources Conference** will be held at the University of Tennessee Space Institute in Tullahoma, Tenn., November 7-9, 1983. The technical program will feature papers reflecting recent developments in operational satellite systems, results from the Shuttle experiments and Landsat 4 investigations, global information systems, advanced sensor systems, image processing, and a broad range of remote sensing applications. Proposals for papers are now being accepted for consideration. To submit a proposal, contact Dr. F. Shahronki, Conference Director, University of Tennessee Space Institute, Tullahoma, TN 37388. As the conference approaches, details on registration will also be available from Dr. Shahronki.

A **Governor's Conference on Applied Remote Sensing, Geographic Data Analysis, and Mapping in Kansas** is scheduled for November 7-8, 1983, in Lawrence, Kansas. Sponsored by the Kansas Governor's Office, the Kansas Interagency Task Force on Applied Remote Sensing, and the Kansas Applied Remote Sensing (KARS) Program, the 2-day conference will be formatted so that each day will be a self-contained unit. The first day will provide background on remote sensing, geographic information systems, and related technologies, backed up by workshops for special-interest groups. The second day will consist of a series of mini-courses that will provide hands-on experience for potential users. For additional information, please contact the Conference Coordinator, KARS Program, University of Kansas, Space Technology Center, Lawrence, KS 66045. Telephone: (913) 864-4775.

An **International Symposium on Microwave Signatures in Remote Sensing** is scheduled to be held January 16-20, 1984, in Toulouse, France. This meeting has been organized by the Centre National d'Etudes Spatiales (CNES) in cooperation with the Centre d'Etudes Spatiale des Rayonnements (CESR) and is co-sponsored by the International Union of Radio Science (URSI). The subject matter will be of interest to specialists who are working directly in the field of radar backscatter and microwave emissions from the Earth and sea, from both a theoretical and experimental focus. Information regarding the technical program can be obtained by contacting Prof. R.K. Moore, Remote Sensing Laboratory, University of Kansas Center for Research, 2291 Irving Hill Drive -Campus West, Lawrence, KS 66045. Arrangements to attend may be made directly with the Centre National d'Etudes Spatiales (CNES), Department des Affairs Universitaires, 18 avenue Edouard-Belin, 31055 Toulouse Cedex, France.

The Environmental Research Institute of Michigan (ERIM) is sponsoring a second thematic conference on **Remote Sensing for Exploration Geology,** April 16-19, 1984, in Colorado Springs, Colo. The meeting will address operational uses of remote sensing in exploration programs as well as future directions for research and development in geologic remote sensing. For additional information, please contact Mr. Donald R. Morris-Jones, Environmental Research Institute of Michigan, P.O. Box 8618, Ann Arbor, MI 48107. Telephone: (313) 994-1200, extension 344.

A **Latin-American Conference and Exhibition on Resource Management** will convene, May 10-16, 1984, in Rio de Janeiro, Brazil. The theme is "Advanced Technologies for Monitoring and Processing Global Environmental Information," with sessions to focus on applications of specific importance to the Latin-American region. This conference and exhibit are part of a continuing series of alternating U.S. and world regional meetings that began in 1981. The list of sponsors is headed by NOAA, NASA, the Inter-American Development Bank, the Remote Sensing Society, the American Planning Association's Energy and Resource Division, and several other organizations. For those wishing to contribute a paper, abstracts are due by December 15, 1983. Complete details on submittals, the technical program, or logistical arrangements are available from Mr. Yale M. Shiffman, Center for Earth Resource Management Applications (CERMA), P.O. Box 2787, Springfield, VA 22152. Telephone: (703) 455-0368.

The **3rd Australasian Remote Sensing Conference** is scheduled for May 21-25, 1984, at Surfers Paradise, Gold Coast, in Queensland, Australia. Hosted by the Queensland Remote Sensing Committee, this year's conference will provide an opportunity for scientists working in the various fields of remote sensing to present current research results and to discuss proposed developments and applications. Themes will include sensor platforms, new techniques, geographic information systems, and mapping. Workshops will form a major part of the conference format. Any inquiries relating to this conference may be addressed to the Secretary, Landsat 84 Conference Committee, P.O. Box 234, Brisbane, North Quay, Queensland 4000, Australia.

The **10th International Symposium on Machine Processing of Remotely Sensed Data,** sponsored by Purdue University's Laboratory for Applications of Remote Sensing (LARS), will take place in West Lafayette, Ind., June 12-14, 1984. Special emphasis will be given to Landsat thematic mapper data and geographic information systems. A call for papers has been issued suggesting topical areas such as scene simulation and modeling, geometric and radiometric preprocessing, stratification and sampling, feature extraction and classifier training, utilization of digitally processed data, and others. Authors interested in contributing papers are invited to submit summaries (500-1,000 words) by December 1, 1983. Further information on this symposium can be obtained from Douglas B. Morrison, Purdue University/LARS, 1291 Cumberland Ave., West Lafayette, IN 47906. Telephone: (317) 494-6305.

The **15th International Congress of Photogrammetry and Remote Sensing** will take place in Rio de Janeiro, Brazil, June 17-29, 1984. Organized and sponsored by the International Society of Photogrammetry and Remote Sensing (ISPRS), this event will be structured around the work of the seven Technical Commissions that help make up the ISPRS. The Commissions focus on subjects such as primary data acquisition, instrumentation for data reduction and analysis, mathematical analysis of data, cartographic and data base applications, the interpretation of photogrammetric and remote sensing data, and others. A call for papers has been issued, with abstracts due by August 1983. For further information on this conference, readers may contact the organizing committee at the following address: Secretaria do XV Congresso da ISPRS; Rua Mexico, 41—Grupo 706—Centro; Rio de Janeiro—RJ—CEP 20031; Brazil. Telephone: (021) 240-6901. Telex: (021) 218959 BR.

A **National Conference on Resource Management Applications** will be held from August 21-25, 1984, in Boston, Mass. Sponsored by the American Planning Association's Energy and Resource

Division, the U.S. Region of the Remote Sensing Society, NASA, NOAA, and a long list of others, the theme of this year's conference is "Advanced Technologies for Monitoring and Processing of Global Environmental Information. The sessions will focus on a variety of domestic applications and issues relating to remote sensing, geographic, and other information systems for energy and environment. A call for papers has been issued with a deadline for abstracts of April 1, 1984. Further information regarding this conference may be obtained by contacting Mr. Yale M. Shiffman, Center for Earth Resource Management Applications (CERMA), P.O. Box 2787, Springfield, VA 22152. Telephone: (703) 455-0368.

TRAINING IN REMOTE SENSING

Oct. 17-21
Terrin Analysis: Interpretation of Aerial Photographs and Images (Sioux Falls, S. Dak.) Contact: Coordinator, Continuing Education Program, Harvard Graduate School of Design, Gund Hall, L-37, Harvard University, Cambridge, MA 02138. Telephone: (617) 495-2578.

Oct. 24-28
Hydrologic Information System Workshop (Sioux Falls, S. Dak.) Open enrollment. Contact: Chief, Training and Assistance, Applications Branch, EROS Data Center, Sioux Falls, SD 57198. Telephone: (605) 594-6114.

Oct. 31-Nov. 4
Spatial Data Base Development (Sioux Falls, S. Dak.) Open enrollment. Contact: Chief, Training and Assistance, Applications Branch, EROS Data Center, Sioux Falls, SD 57198. Telephone: (605) 594-6114.

Oct. 31-Nov. 4
Remote Sensing: A Tool for Soil Surveys and Resource Inventories (Brookings, S. Dak.) Contact: Nancy Dameron, Remote Sensing Institute, South Dakota State University, P.O. Box 507, Brookings, SD 57007. Telephone: (605) 688-4184.

Nov. 7-11
Use of Geographic Information System for Analysis of Soil Survey and Resource Inventory Data (Brookings, S. Dak.) Contact: Nancy Dameron, Remote Sensing Institute, South Dakota State University, P.O. Box 507, Brookings, SD 57007. Telephone: (605) 688-4184.

Nov. 14-18
Advanced Geologic Workshop (Sioux Falls, S. Dak.) Open enrollment. Contact: Chief, Training and Assistance, Applications Branch, EROS Data Center, Sioux Falls, SD 57198. Telephone: (605) 594-6114.

Nov. 15-17
Workshop on Color Aerial Photography in the Plant Sciences (Orlando, Fla.) Sponsored by American Society of Photogrammetry. Contact: Janet D. Degner, Department of Civil Engineering, 346 Weil Hall, University of Florida, Gainsville, FL 32611. Telephone: (904) 392-4999.

Nov. 22-29
Computer Assisted Cartography (New Dehli, India) In collaboration with the International Cartographic Association. Contact: Dr. M.K. Munshi, Superintending Surveyor, Office of the Director, Survey of India, West Block No.4, Ramakrishnapuram, New Dehli—110022, India.

Nov. 28-Dec.2
Remote Sensing in Land Use Studies (Brookings, S. Dak.) Contact: Nancy Dameron, Remote Sensing Institute, South Dakota State University, P.O. Box 507, Brookings, SD 57007. Telephone: (605) 688-4184.

Dec. 5-9
Geographic Information Systems in Remote Sensing (Brookings, S. Dak.) Contact: Nancy Dameron, Remote Sensing Institute, South Dakota State University, P.O. Box 507, Brookings, SD 57007. Telephone: (605) 688-4184.

Dec. 5-9
Role of Remote Sensing in a Geographic Information System (Sioux Falls, S. Dak.) Open enrollment. Contact: Chief, Training and Assistance, Applications Branch, EROS Data Center, Sioux Falls, SD 57198. Telephone: (605) 594-6114.

Dec. 5-9
Numerical Analysis of Remote Sensing Data (West Lafayette, Ind.) Contact: Douglas B. Morrison, Laboratory for Application of Remote Sensing (LARS), Purdue University, 1291 Cumberland Avenue, West Lafayette, IN 47506. Telephone: (317) 494-6305.

Dec. 12-16
Digital Image Processing in Remote Sensing (Brookings, S. Dak.) Contact: Nancy Dameron, Remote Sensing Institute, South Dakota State University, P.O. Box 507, Brookings, SD 57007. Telephone: (605) 688-4184.

Dec. 19-23
Advanced Workshop on Remote Sensing and Mapping (Tucson, Ariz.) Contact: Mike Parton, Arizona Remote Sensing Center, Office of Arid Land Studies, College of Agriculture, University of Arizona, 845 North Park Avenue, Tucson, AZ 85719.

Mar. 5-9
Numerical Analysis of Remote Sensing Data (West Lafayette, Ind.) Contact: Douglas B. Morrison, Laboratory for Application of Remote Sensing (LARS), Purdue University, 1291 Cumberland Avenue, West Lafayette, IN 47906. Telephone: (317) 494-6305.

Apr. 23-May 25
International Workshop: Applications in Geologic and Hydrologic Exploration and Planning (Sioux Falls, S. Dak.) Open to non-U.S. scientists only. Contact: Office of International Geology, U.S. Geological Survey, National Center (Mail Stop 917), Reston, VA 22092.

Jun. 4-8
Numerical Analysis of Remote Sensing Data (West Lafayette, Ind.) Contact: Douglas B. Morrison, Laboratory for Application of Remote Sensing (LARS), Purdue University, 1291 Cumberland Avenue, West Lafayette, IN 47906. Telephone: (317) 494-6305.

Aug. 27-Sep. 28
International Workshop: Applications in Vegetation Assessment and Land Use Planning (Sioux Falls, S. Dak.) Open to non-U.S. scientists only. Contact: Office of International Geology, U.S. Geological Survey, National Center (Mail Stop 917), Reston, VA 22092.

PECORA VIII

"Satellite Land Remote Sensing Advancements for the Eighties" is the theme of the **Eighth William T. Pecora Symposium** to be held October 4-7, 1983, in Sioux Falls, South Dakota. Pecora VIII shifts the emphasis from remote sensing applications, the overall theme of previous symposia in this series, to an overview of both U.S. and international plans and policies for satellite remote sensing in the future. The sponsors are NOAA, NASA, and the U.S. Geological Survey, all of whom are scheduled to talk about their respective plans for land remote sensing in the remainder of this decade.

Current proposals and viewpoints on the future of U.S. remote sensing satellite programs will be addressed by Administration and Congressional officials. Representatives from U.S. industry will present plans for private sector operation of civil satellites. In addition, future Space Shuttle remote sensing activities will be covered, including advanced imaging systems such as the Large Format Camera and multilinear arrays.

Invited theme papers will describe plans for a National Digital Cartographic Data Base, the National High-Altitude Photography Program, and the emerging analytical capabilities of microcomputers in remote sensing applications. Papers on the Landsat 4 thematic mapper instrument will describe its current performance as well as plans for its future use.

The 4-day meeting will feature sessions on:

- Land Remote Sensing Plans, Policies, and Activities—presentations by NASA, NOAA, and the U.S. Geological Survey.
- Invited papers on Landsat 4 Results—reflecting work in progress by Landsat 4 principal investigators and others. Chaired by Vincent Salomonson, Chief, Earth Survey Applications Division, NASA.
- Applications and Related Technology—providing information on the capabilities and applications of radar, aircraft, and meteorological data, including how they fit in with geographic data bases using other kinds of remote sensing data. Chaired by Donald T. Lauer, Chief, Branch of Technique Development and Applications, USGS/EROS Data Center.
- Future Operational Satellites: Plans and Status—covering SPOT, Radarsat, Fairchild's Leasecraft Project, the German GEO-SPAS platform, and others. Chaired by Pitt G. Thome, President, the Destek Group.
- Future Operational Satellites: The French SPOT Program—presenting several papers devoted to the SPOT development effort and simulation campaign. Chaired by Gilbert Weill, Director, SPOT Image Corporation, U.S.A.
- Future Space Shuttle Experiments—including efforts on a Shuttle-mounted multi-linear array radiometer, the Large Format Camera, a Shuttle imaging spectrometer, and digital topographic mapper. Chaired by Mark Settle, Landsat 4 Program Scientist, NASA Office of Space Science and Applications.

The registration fee for Pecora VIII is $95. Tours of the EROS Data Center will be availale, and all participants will receive a bound volume of the proceedings. The symposium will be preceded on October 3 by a NOAA Public Meeting on the Landsat Program for those wishing to hear or offer public comments on Landsat activities.

The Pecora Symposia were established in 1975 to foster the exchange of scientific and resource management findings resulting from the use of remotely sensed data. The symposium series honors the memory of William T. Pecora, former director of the U.S. Geological Survey and Undersecretary of the Department of the Interior. Dr. Pecora played a major role in the development and establishment of this country's satellite remote sensing system.

Complete information regarding registration, how to obtain the proceedings, or other details concerning Pecora VIII may be obtained by contacting:

Pecora VIII Symposium
P.O. Box 80937
Sioux Falls, SD 57116
Telephone: (605) 594-2281.

A sampling of specific papers to be presented during the 4-day meeting follows below:

The Evolution and Present Status of the Landsat 4 System
Vincent Salomonson

Data Products and Processing Procedures
John Lyons, Interpretive Techniques Branch NASA/Goddard Space Flight Center

Thematic Mapper Image Processing System (TIPS) Performance
Eric P. Beyer, General Electric Company Valley Forge Space Center

Landsat 4 Sensor Performance
John Barker, Earth Resources Branch NASA/Goddard Space Flight Center

Thematic Mapper—Detailed Radiometric and Geometric Characteristics
Hugh Kieffer, U.S. Geological Survey Flagstaff, Arizona

Landsat 4 Thematic Mapper Sensor Evaluation and Advanced Information Extraction Experiments
Ralph Bernstein and Jeffery B. Lotspiech, IBM Palo Alto Scientific Center

Radiometric Analyses of Landsat 4 Digital Image Data
William Malila, Daniel Rice, and Michael Metzler, Environmental Research Institute of Michigan

Landsat 4 Quality Evaluation Results
P.E. Anuta, L.A. Bartolucci, M.E. Dean, C.D. McGillem, and E. Malaret, Laboratory for Applications of Remote Sensing
Purdue University

Cartographic Quality of Landsat 4 MSS and TM Image Data
R. Welch, Department of Geography University of Georgia

Analysis of Landsat 4 Thematic Mapper Data for Classification of Forest in Baldwin County, Alabama
C.L. Hill, National Space Technology Laboratories, NASA/Earth Resources Laboratory

Evaluation of Thematic Mapper Data for Natural Resource Assessment Robert Haas and Fred Waltz, Technicolor Government Services, Inc.

Agricultural Applications of TM Data
David E. Pitts, R. Bizzell, K. Henderson, and D.R. Thompson, NASA/Johnson Space Center and C. Sorenson and J. Carnes, Lockheed Engineering and Management Corporation

Evaluation of Landsat 4 Image Quality for the Interpretation of Forest, Agricultural, and Soil Resources
Stephen D. De Gloria, Remote Sensing Research Program, University of California

TM Data Enhancement and Geological Findings
John Everett, Earth Satellite Corporation

Lithologic Mapping Using Landsat Thematic Mapper Data
M.H. Podwysocki, J.W. Salisbury, O.D. Jones, and D.L. Mimms, U.S. Geological Survey

Geologic Applications of SideLooking Airborne Radar Data in the Central Appalachians
Howard A. Pohn, U.S. Geological Survey

The National Digital Cartographic Data Base
Eric Anderson, U.S. Geological Survey

The National High-Altitude Photography Program
Peter Bermel, U.S. Geological Survey

Application of Metsat Data in Land Remote Sensing
George Ohring, NOAA/National Environmental Satellite Data and Information Services

The Emerging Analytical Capabilities of Microcomputers
William Erickson, NASA/Ames Research Center

New Opportunities for the Private Sector in Remote Sensing
Doug Carter, Remote Sensing Consultant in Geology

The Advanced Earth Resources Observations Satellite (AEROS), a Private Sector Remote Sensing Space System
N.H. MacLeod, American Science and Technology Corporation

COMSAT's Current Plan for Land Remote Sensing Systems
Paul Maughan, COMSAT General Corporation

The Fairchild Leasecraft Project
John Naugle, Fairchild Space and Electronics Company

The GEOSAT Committee's Current Activities and Plans
Fred Henderson, GEOSAT Committee

The Large Format Camera
Fred Doyle, U.S. Geological Survey

GEO-SPAS, A New Approach for Commercialization of Remote Sensing
G. Barthel, Hans-Christian Benohr, and B.E. Koelle, MBB Space Division, Federal Republic of Germany

RADARSAT
Ed Langham, Radarsat Project Office, Canada

Mapsat
Alden Colvovoresses, U.S. Geological Survey

Multilinear Array Instrument Concepts for Future Land Remote Sensing
Aram Mika, Hughes Aircraft Company

SPOT System Conception and Program Status
Michel Courtois, Centre Spatial De Toulouse

Flexible Programming for SPOT System
M. Cabrieres

Integration of Oblique Space Imagery into Geographic Data Bases
M. Denegre

The GDTA SPOT Simulation Program
J.C. Cazaux, CNES/Toulouse

The 1983 U.S. SPOT Simulation Campaign
G. Weill, SPOT Image

Optical and Biological Land Cover Using a Shuttle-Mounted Multilinear Array Radiometer
Vincent Salomonson, NASA/Goddard Space Flight Center

Shuttle Imaging Spectrometer
Alexander Goetz, Jet Propulsion Laboratory

Multispectral Imaging in Thermal Infrared from Shuttle
Anne Kahle, Jet Propulsion Laboratory

Orbital Surveys of Solar Stimulated Luminescence
W.R. Hemphill, U.S. Geological Survey, Reston, Virginia, A.F. Theisen, R.M. Tyson, and J.S. Granata, U.S. Geological Survey,
Flagstaff, Arizona

Shuttle Imaging Radar Research Facility
C. Elachi, J.B. Cimino, and D. Evans, Jet Propulsion Laboratory

Shuttle Digital Topographic Mapper
Michael Kobrick, Jet Propulsion Laboratory

Shuttle Polar Ice Sounding and Altimetry
T.H. Dixon and C. Elachi, Jet Propulsion Laboratory

Man-Tended Multisensor Satellites for Earth Resources
Dixon Butler, NASA/Space Sciences and Applications

LANDSAT 4 MONTHLY OPERATIONAL SUMMARY
August, 1983

ORBITAL CHARACTERISTICS

International Designation	1982-072A
Catalog Number	8707201
Launch Date	16 July, 1982
Date Operations Began: MSS	20 July, 1982
TM	17 August, 1982
Days Operational (this period)	31
Orbit Angle	98.2040°
Average Altitude	699.60 km 434.71 miles
Equator Crossing Time: descending	09:39 a.m. local
ascending	09:42 p.m. local
Precession Rate	-0.30 minutes/month
Hydrazine Remaining	494.46 lbs
Orbit Nodal Period	98.76 minutes
Last Orbit Adjust	16 August, 1983
Next Orbit Adjust	October, 1983

GROUND STATION STATUS AND CAPABILITIES

(T=Telemetry, C=Command, S=MSS Sensor)

U.S.:

NOAA Transportable Ground Station, Greenbelt	T S	Operational
NASA GSTDN Fairbanks, Alaska	T C S	Operational
NASA GSTDN Goldstone, California	T C S	Operational
NASA GSTDN (Others)	T C	Operational
TDRSS White Sands, New Mexico	T C S	System Test

Foreign:

Argentina, Mar del Plata		System Upgrade
Australia, Alice Springs	S	Operational
Brazil, Cuiada	S	Operational
Canada, Prince Albert	S	Operational
India, Hydernabad	S	Operational
Italy, Fucino	S	Operational
Japan, Tokyo	S	Operational
South Africa, Johannesburg	S	Operational
Sweden, Kiruna	S	Operational
Thailand, Bangkok	S	Operational

SENSOR STATUS

MSS	Operational
TM	Operational

DOMESTIC SCENES ACQUIRED

MSS	2219 (40 TDRS)
TM	64 TDRS (14 processed)

SPACECRAFT STATUS OVERVIEW

Attitude and Orbit:	
Modular Attitude Control Subsystem	Nominal
Power Module	Nominal
Communications and Data Handling:	
Communications and Data Handling	Nominal
Narrow Band Tape Recorder No. 1	Servo errors at start of tape
Narrow Band Tape Recorder No. 2	Nominal
Signal Conditioning and Control Unit	Nominal
Digital Processing Unit	Nominal
Power and Thermal:	
Modular Power Subsystem	Nominal
Power Distribution Unit	Nominal
Solar Array Drive & Power Transfer Assembly	Nominal
Solar Panel 1	Operational
Solar Panel 2	Operational
Solar Panel 3	Failed
Solar Panel 4	Failed
Operational Solar Array Offset	-34°
Transmitters:	
Unified S-band	Nominal
S-band	Nominal
X-band	Failed, 15 Feb 1983
Ku-band	Nominal
Global Positioning System	Off

REMARKS:

No systematic changes were noted in the MSS instrument during this period. Last NOAA sensor calibration was performed on April 1, 1983.

Landsat 4 was used to support TDRSS testing during this period and performed exceptionally well. TDRS experienced problems with the auto-track mode of operation.

A full MSS operational mission continues to be supported. No further TM scheduling is expected to take place until after November 1, 1983.

The Landsat Data Users NOTES is published quarterly in order to present information of interest to the user community regarding Landsat products, systems, and related remote sensing developments. There is no subscription charge; individuals and organizations wishing to receive the NOTES should contact: NOAA Landsat Customer Services, Mundt Federal Building, Sioux Falls, SD 57198, U.S.A., Telephone: (605) 594-6151, FTS: 784-7151.

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